A STUDY OF THE EFFECT OF DIFFERENT ADMIXTURES ON THE WORKABILITY OF CONCRETE

Thesis for the Degree of B. S.
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William E. Johnson

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A STUDY OF THE EFFECT OF DIFFERENT ADMIXTURES ON THE WORKABILITY OF CONCRETE

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ACKNOWLEDGMENT

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William E. Johnson

INTRODUCTION

Introduction

It was the purpose of this study to find the effect of several of the common admixtures on the workability of the concrete mix. The number of admixtures used, however, was limited by the time permitted for the preparation of this report.

With different text books and authorities the concept of an admixture varies. Therefore, to make clear what is meant by an admixture in this report, a definition will be stated that agrees with the author's concept. "An admixture is any material added to a concrete or mortar mix other than water, cement, fine aggregate, or coarse aggregate to impart a primary desired condition." In some cases, however, one desired condition may be sacrificed to a small extent to favor another. An example of this would be adding an air-entraining agent to increase percentage of air voids, but perhaps, decreasing strength slightly.

Admixtures for use in concrete are classed on their ability to promote certain basic actions in concrete mixes. These classifications are as follows:

1. Dispersing Agents
2. Accelerators
3. Water Proofing Pastes
4. Plasticizing Agents
5. Finely Divided Powders
6. Air Entraining Agents

7. Retarders

8. Miscellaneous

At one time a number of materials classed as admixtures for concrete were widely promoted as being capable of ridding concrete of all kinds of ills, and as a result admixtures became little thought of as being useful because few of the materials actually produced what was claimed in their favor. Recent advances in the development of admixtures and in the understanding of their proper use have, however, led to the acceptance of the fact that if selected properly and used in the right proportions, they offer a satisfactory means of producing specific, desired results. A knowledge of what an admixture will or will not do should permit design of concrete for the desired end to the best advantage.

For this report five admixtures were selected for investigation as to their effect on workability. The admixtures used were all common ones used to promote varied primary desired conditions. No attempt, whatsoever, was made to test these admixtures for any other conditions that they might create. In this experimentation the only objective in mind was the effect upon the degree of workability.

Also, no distinction was made as to qualification in any certain class. The first two, Vinsol resin and Orvus, are known chiefly as air entraining agents. The next, Pozzolith, is a dispersing agent. The accepted use for Calcium Chloride as an admixture is for decreasing the time of set, Hydrated Lime is known mostly as a plasticizing agent.

DISCUSSION

VINSOL RESIN

Vinsol resin is a by-product of the naval stores industry, and was originally used as an insoluble resin interground with the Portland cement clinker. Vinsol resin may, however, if neutralized with a caustic solution,be added at the mixeras well as ground with the cement clinker. It is added by either method usually in amounts varying from one to three one hundredths of one percent. In this research the neutralized Vinsol resin was added in varying amounts up to one percent to find if there was any continued effect on workability at the upper limits, realizing however, that other conditions whollyunsatisfactory may be introduced.

Vinsol Resin, either when interground or added at the mixer, tends to entrain a considerable amount of air and causes the concrete or mortar to be more cohesive or fatty. A difficulty withVinsol resin is that it causes a variable behavior. The same percentage added to identical mixes may produce widely different results in some cases. This variation implies that the effectiveness of the Vinsol resin withrespect to air-entrainment, bleeding, segregation, fattiness,durability and strength will also vary. In the present state of knowledge results show that these variations are unpredictable. This means that the precise desired properties are hard to obtain with Vinsol resin. The reason for this variation seems to lie in the fact that the air-entraining action of the resin is dependent upon neutralization or saponification of the resin by the alkalies of the cement. This has led to pre-neutralization of the Vinsol resin with a caustic soda solution. While this measure has improved performance, it has by no means eliminated variation. In any case property variations depend upon degree of saponification.

ORVUS

Orvus is a product made by Proctor and Gamble Co. Its greatest constituent is sodium lauryl sulphate. As compared with Vinsol resin laboratory tests show that addition of Orvus to the mix have similar effects on most properties. Unlike Vinsol resin, it does not impair strength, but shows an increase at all ages. Orvus is a definite chemical compound produced synthetically, and does not cause variability such as Vinsol resin.

POZZOLITH

Pozzolith is a product made by Master Builder's Company. It is a dispersing agent . Like the two air entraining agents already discussed, it is an approach to the problem of the improvement of properties of Portland cement. Application of the dispersion principle was developed in the early 1930's. It is today used both in building construction and pavement work.

When Portland cement is mixed with water, the individual particles tend to gather together and stick to each other; afloc is formed. This floc is due to lack of mutually repellant electrostatic charges on cement particles. It is the purpose of a dispersing agent introduced into the mix to break up this floc, and makethe cement act as individual particles.

Dispersion of the cement produces three important effects. The water which was trapped among the floc is liberated to become part of the mixing water. The surface area of the cement particles, through dispersion,becomes greatly increased. A certain amount of air is entrained, and thus, a dispersing agent also becomes an air-entraining agent.

Dispersion, through those three important effects, would indicate production of a higher strength concrete, better workability, greater water tightness by making possible a reduction in water-cement ratio, greater durability with respect to freezing and thawing and resistance to corrosion.

CALCIUM CHLORIDE

Calcium Chloride is used as an accelerator. Often it is necessary to accelerate setting or hardening or both. A great many inorganic electrolytes will serve this need. The most widely used which is typical of the group of inorganic electrolytes is Calcium Chloride. This compound is used because it is most economical and available. It is commonly used in quantities up to three percent of the weight of the cement.

HYDRATED LIME

Oneof the admixtures most commonly used for improving workability is hydrated lime. It is used in amounts up to five pounds per bag of cement. Contractors using hydrated lime as an admixture report that they get, especially with the leaner mixes, more uniform concrete from batch to batch than when they do not use it. Because of the extreme fineness of lime, it reduces to a minimun the effects of small variations in amounts of mixing water on the consistency of the concrete.

PROCEDURE

PROCEDURE

In a research problem like this there can be only two variables. One of the variables is one of the constituents, and the other is a result which may or may not vary. In this report the water-cement ratio, the amount of cement, andthe gradation of the aggregate was kept constant. The kind of cement and aggregate was also kept the same throughout. Only the admixture was varied.

It was decided at the beginning of the experimentation to take five common admixtures and thoroughly investigate their flow properties when varying percentages of admixtures were added to the mix. For these tests the slump and flow table were used according to A.S.T.M. method of tests.

For slump tests the fine and coarse aggregates were combined in proportions so that the combination would approach the ideal grading based upon Weymouth's theory of particle interference. Several trials showed that this ideal mix was most closely approached with a fifty percent fine and fifty percent coarse aggregate combination than with any other.

A mix of 1:5.5 by weight with a water cement-ratio of eight tenths by volume or fifty three one hundredths by weight was used for the slump tests. Any pebbles in the aggregate coarser than three-fourths inch were graded out. For each different percentage of admixture incorporated in the mix, three separate batches were made. One slump test was taken from each batch. The curves were plotted from an average of these.

Only fine aggregate was used for the flow table test, as this is chiefly a test for mortars. Consistent results could not be obtained when using a combination of both aggregates. Although a different gradation will, perhaps, effect the mix differently as to degree of workability, the general effect should be the same regardless of gradation. The mix was the same in proportion of cement to aggregate as in the slump test, but with a water-cement ratio of seventy three one hundredths by weight. This increase in water was necessary to obtain a workable consistency because, perhaps, of the greater percentage of air voids in a finer graded aggregate.

With each percentage of admixture three separate batches were made. From each batch two flow table tests were taken, and from an average of these results the curves were plotted.

It is known that the degree of workability varies with the time of mixing to some extent. It was therefore important to keep the mixing time as near constant as possible. Each batch was mixed from two to two and one half minutes by hand. At the end of this period of mixing the workability seemed to remain fairly constant.

All the aggregate, fine and coarse, was dried by gas burner until the water content was reduced as much as possible. None of the aggregate was used the same day that it was dried so as to be sure not to use any above room temperature. In small batches such as were used, it would be impossible to calculate the amount of water present and allow for it in the mix.

Below is tabulated the seive analysis data for the fine and coarse aggregates. This represents an average of two tests.

Seive Size	Percent Passing		50% Sand	50% Pebbles	Combined
	Sand	Pebbles			
100	2	0	1	0	1
50	14	0	7	0	7
30	39	0	19.5	0	19.5
16	59	0	29.5	0	29.5
8	80	4	40	2	42.0
4	93	5	46.5	2.5	49.0
¼	95	6	47.5	3.0	50.5
3/8	100	13	50	6.5	56.5
½	100	42	50	21.0	71.5
3/4	100	100	50	50.0	100.0

TEST DATA

AND

CURVES

VINSOL RESIN

Flow Table

Percent Admixture	Percent Flow		
0.00	120,116	116,116	120,112
.03	120,120	125,116	125,125
.09	125,120	132,132	125,130
.12	125,125	125,130	130,130
.20	142,137	142,137	142,132
.30	132,148	143,150	137,145
.50	148,150	158,150	145,155
1.00	155,162	160,155	162,160

Slump Cone

Percent Admixture	Inches Slump		
0.00	1	$1\frac{1}{4}$	$1\frac{1}{4}$
.03	1	$1\frac{1}{2}$	$1\frac{1}{2}$
.09	2	$2\frac{1}{2}$	$2\frac{1}{2}$
.12	2	$2\frac{1}{2}$	$2\frac{1}{2}$
.30	3	3 3/4	$3\frac{1}{2}$
1.00	3	4	$4\frac{1}{2}$

ORVUS

Flow Table

Percent Admixture	Percent Flow		
0.00	130,125	125,125	
.03	145,145	132,125	142,137
.09	140,137	140,137	142,142
.12	150,155	150,150	155,152
.20	167,169	167,165	160,167
.30	170,166	159,186	178,175
.50	180,182	182,180	163,180
1.00	182,185	168,170	180,185

Slump Cone

Percent Admixture	Inches Slump		
0.00	$1\frac{1}{2}$	$1\frac{1}{2}$	2
.03	$1\frac{1}{2}$	2	$2\frac{1}{2}$
.09	2 3/4	3	$3\frac{1}{4}$
.12	3	$3\frac{1}{4}$	$3\frac{1}{4}$
.30	3 3/4	4	4
1.00	$5\frac{1}{2}$	5	$5\frac{1}{2}$

POZZOLITH

Flow Table

Per cent Admixture	Percent Flow		
0.00	125,125	131,133	131,131
.50	133,137	137,130	125,132
1.00	137,137	140,135	143,140
1.50	150,150	156,153	148,153
2.00	162 ,156	156,156	152,158
3.00	155,163	166,169	165,165
4.00	177,177	184,187	168,175
5.00	177,188	187,187	180,188

Slump Cone

Percent Admixture	Inches Slump		
0.00	1½	1½	1½
.50	2½	2½	3
1.00	3	3	3½
1.50	4	4	3½
3.00	4¼	4 3/4	4 3/4
5.00	5½	5½	5

HYDRATED LIME

Flow Table

Percent Admixture	Percent Flow		
0.0	130,125	127,125	
1.0	120,127	125,127	125,127
2.0	130,125	125,127	127,125
3.0	130,130	130,125	130,130
5.0	130,135	125,125	135,135

Slump Cone

Percent Admixture	Inches Slump		
0.0	1	1½	1½
1.0	1	2	2
2.0	2	2	2
3.0	2	2	2½
5.0	2½	2½	3

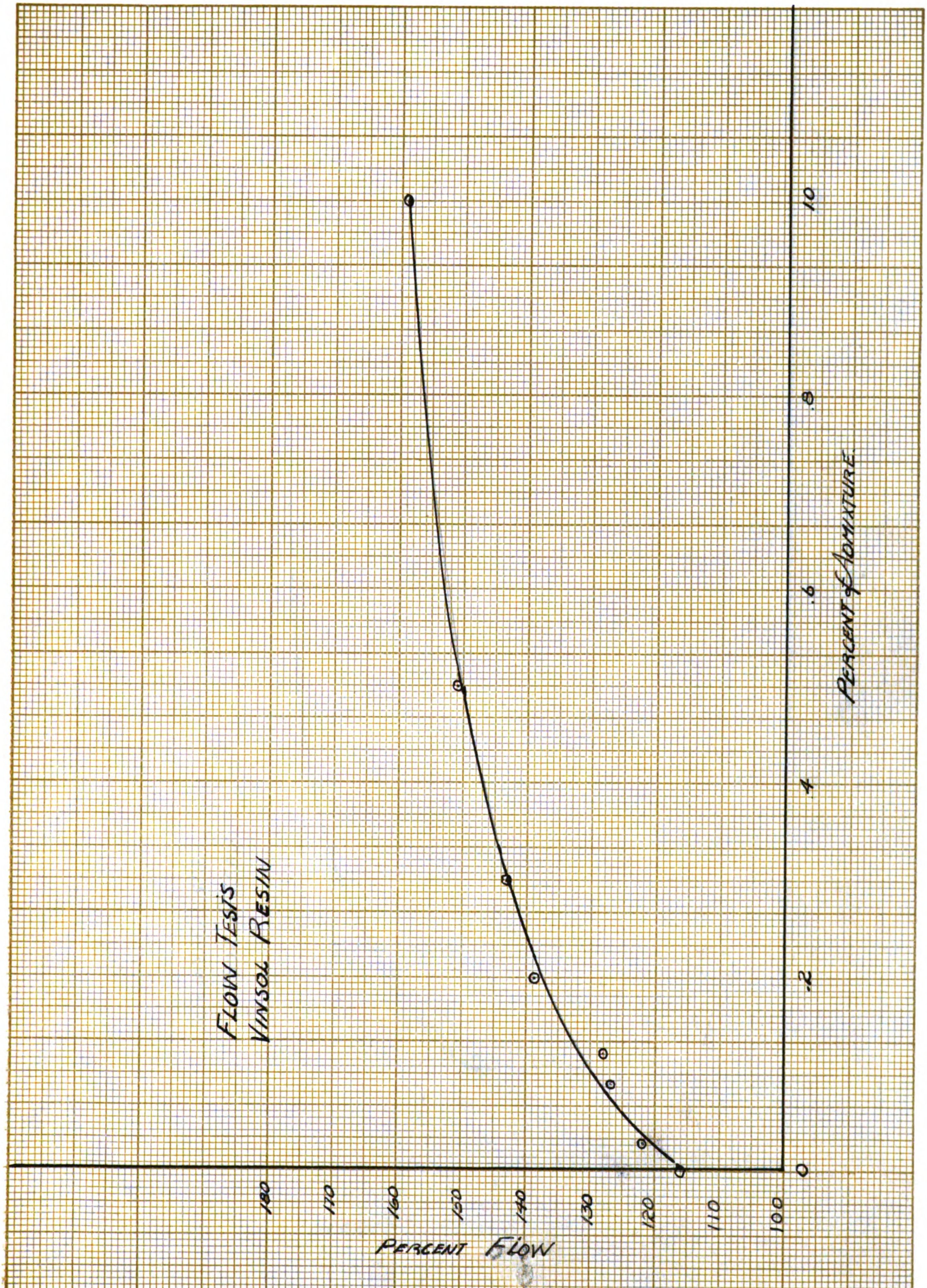
CALCIUM CHLORIDE

Flow Table

Percent Admixture	Percent Flow		
0.0	125,127	125,127	127,127
1.0	130,125	125,125	127,127
3.0	130,130	130,125	130,127
5.0	135,135	130,130	125,130

Slump Come

Percent Admixture	Inches Slump		
0.0	1	1 3/4	1½
1.0	3	1½	1½
3.0	2	2	2
5.0	2½	3	2


FLOW TESTS
VINSOL RESIN
PERCENT FLOW
PERCENT ADMIXTURE
100
110
120
130
140
150
160
170
180
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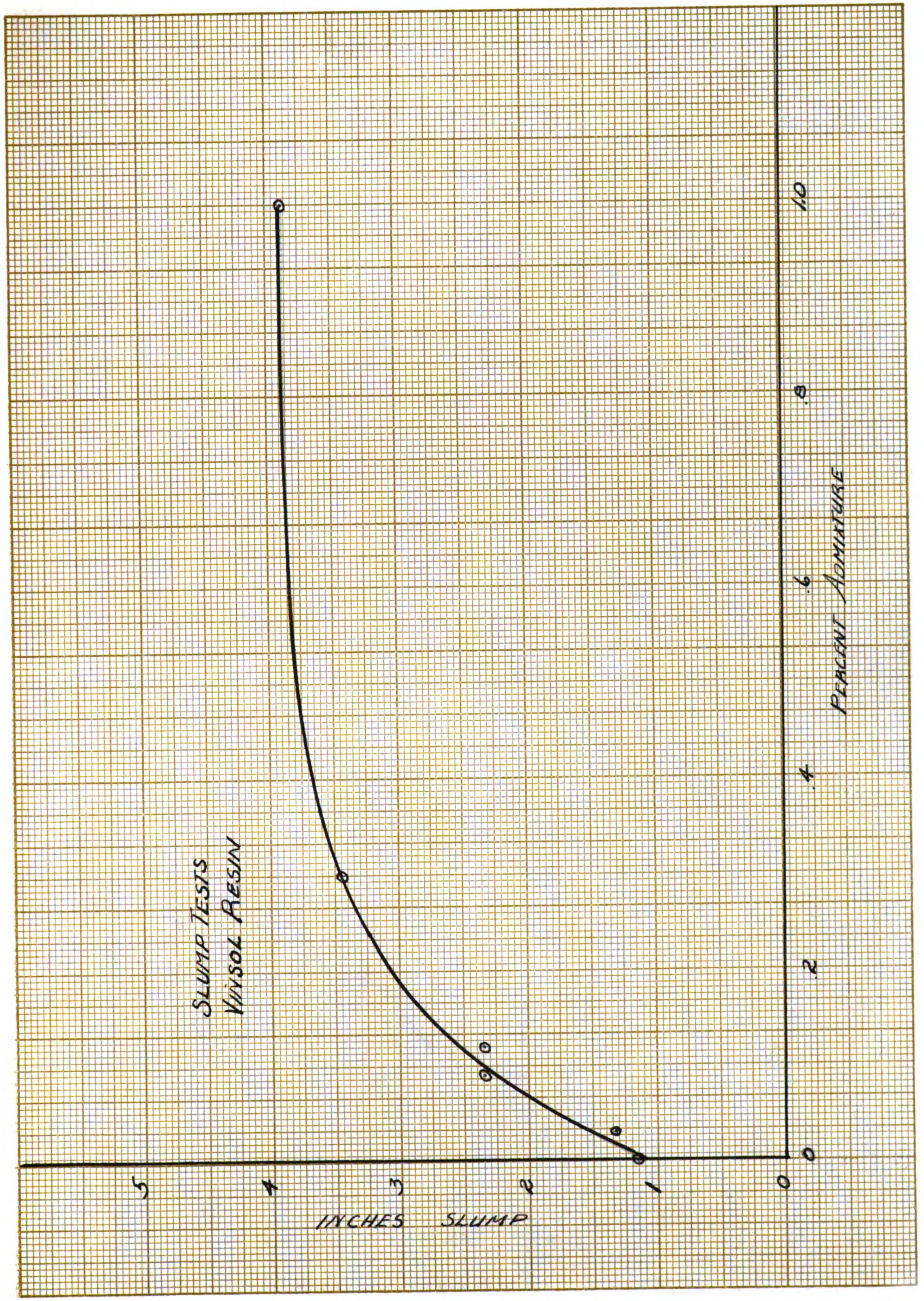
.2
.4
.6
.8
1.0


SLUMP TESTS
VINSOL RESIN
PERCENT ADMIXTURE
INCHES SLUMP
0
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.4
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.8
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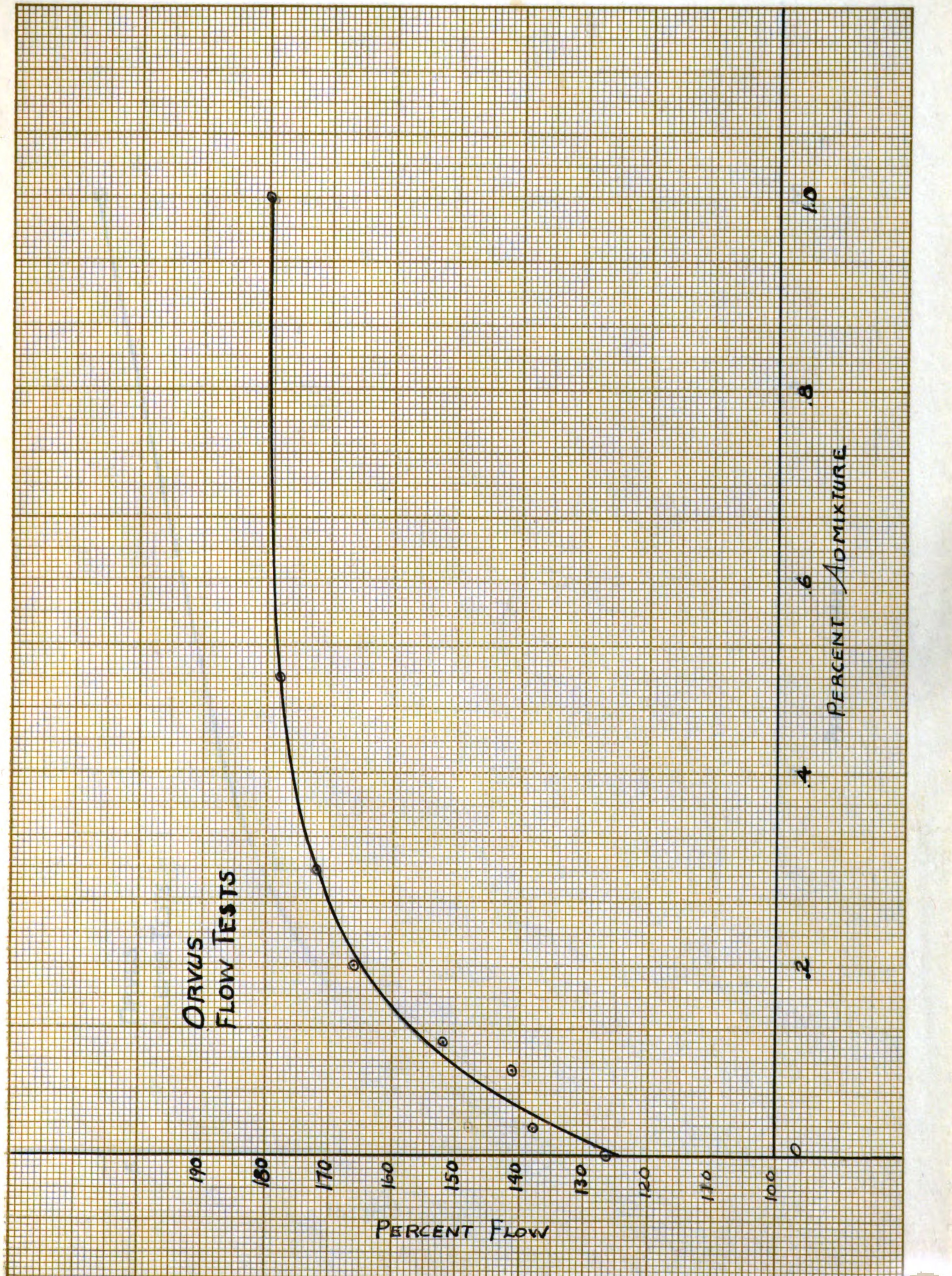
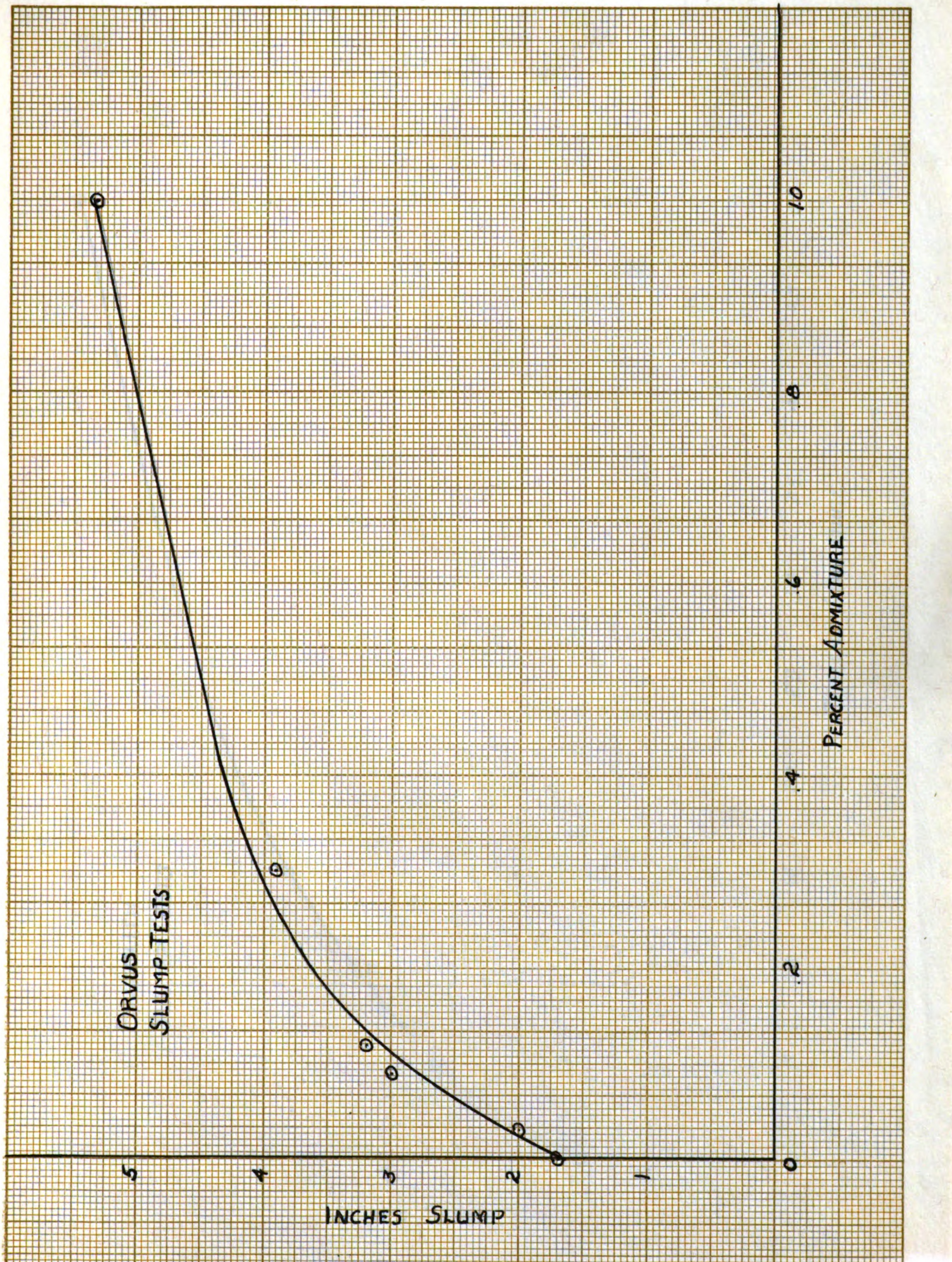
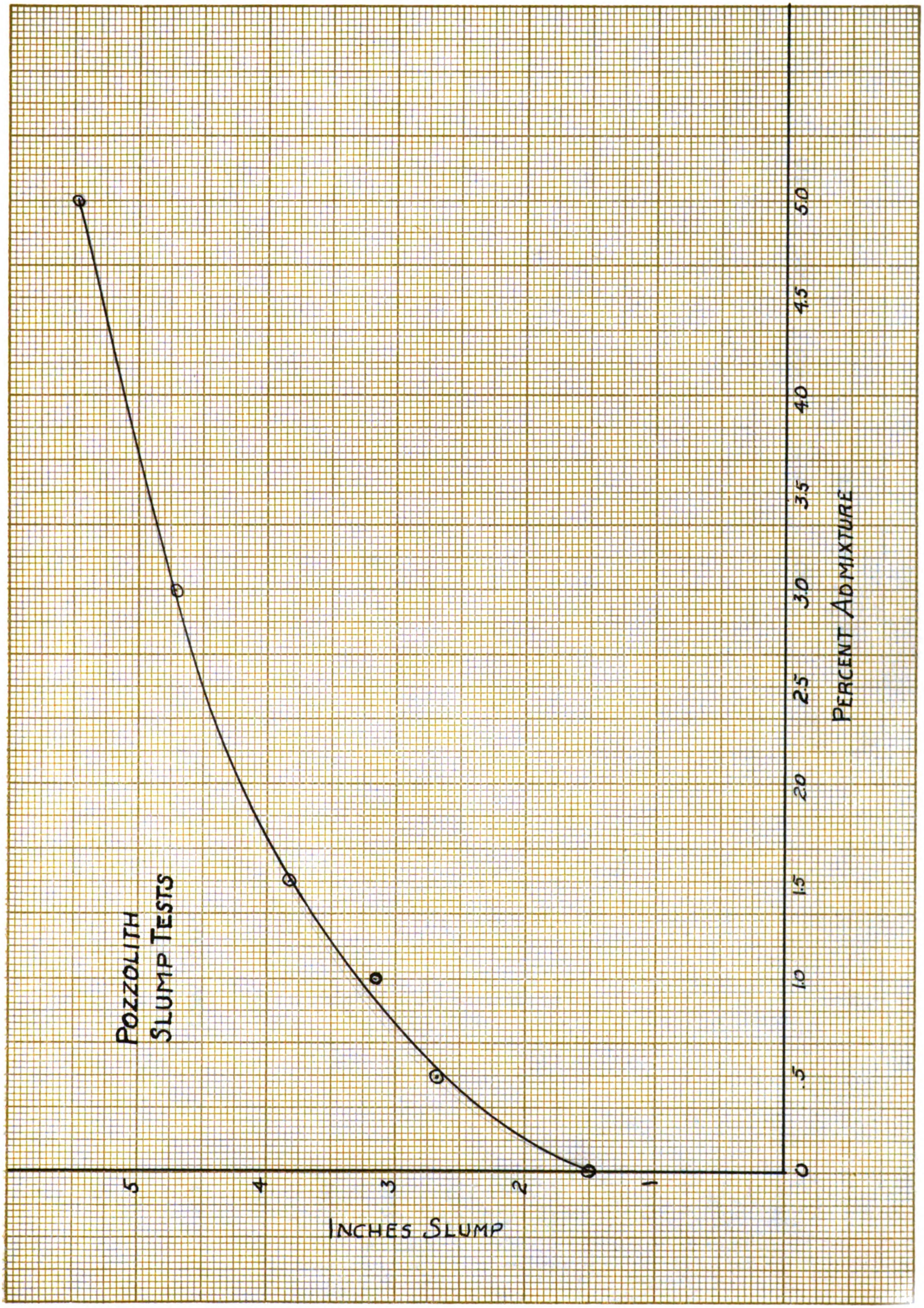
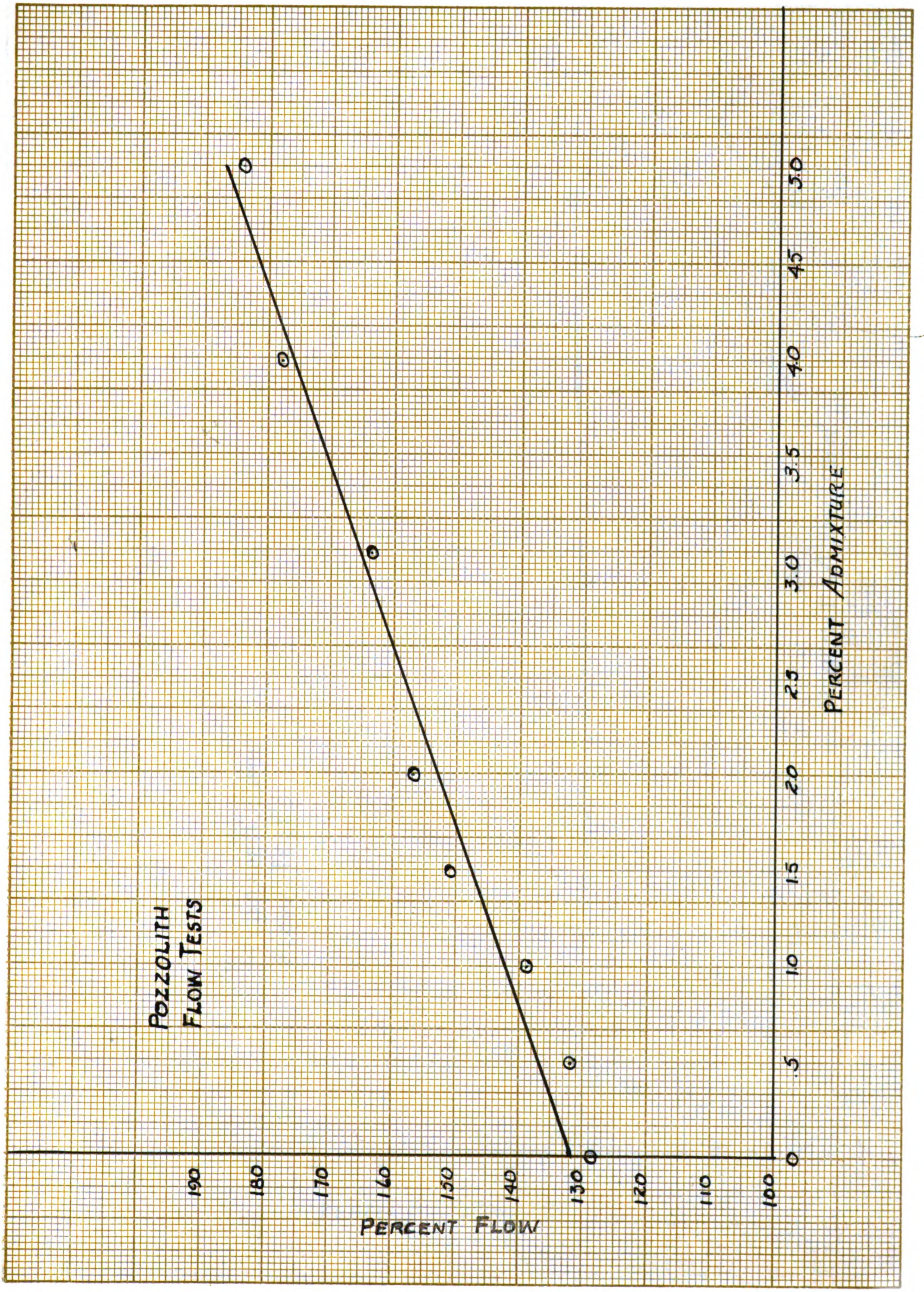
0
1
2
3
4
5


ORVUS
FLOW TESTS
PERCENT ADMIXTURE
0
.2
.4
.6
.8
1.0
PERCENT FLOW
190
180
170
160
150
140
130
120
110
100


ORVUS
SLUMP TESTS
PERCENT ADMIXTURE
0
.2
.4
.6
.8
1.0
INCHES SLUMP
1
2
3
4
5


POZZOLITH
SLUMP TESTS
PERCENT ADMIXTURE
0
.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
INCHES SLUMP
1
2
3
4
5


POZZOLITH
FLOW TESTS
PERCENT FLOW
100
110
120
130
140
150
160
170
180
190
PERCENT ADMIXTURE
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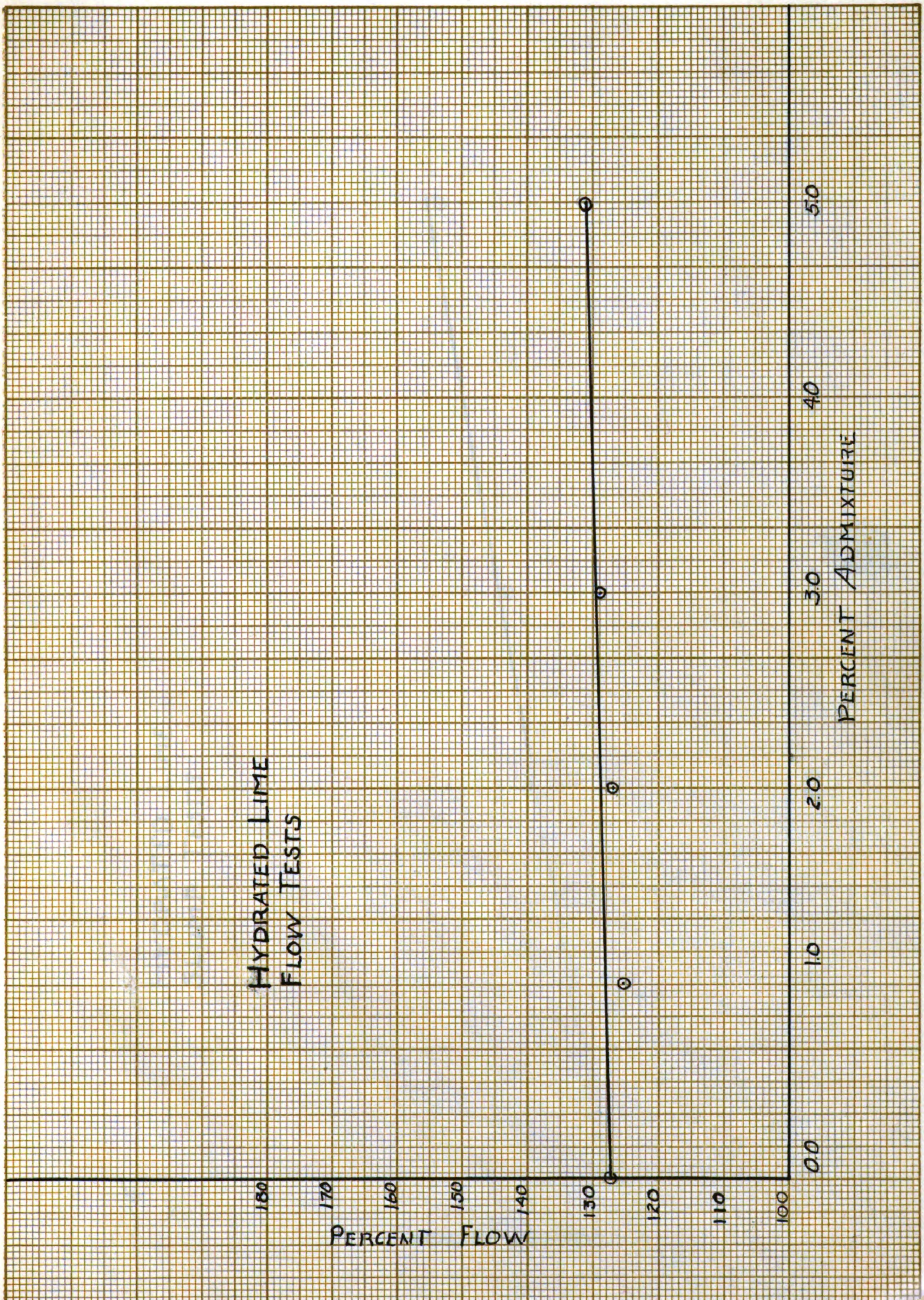
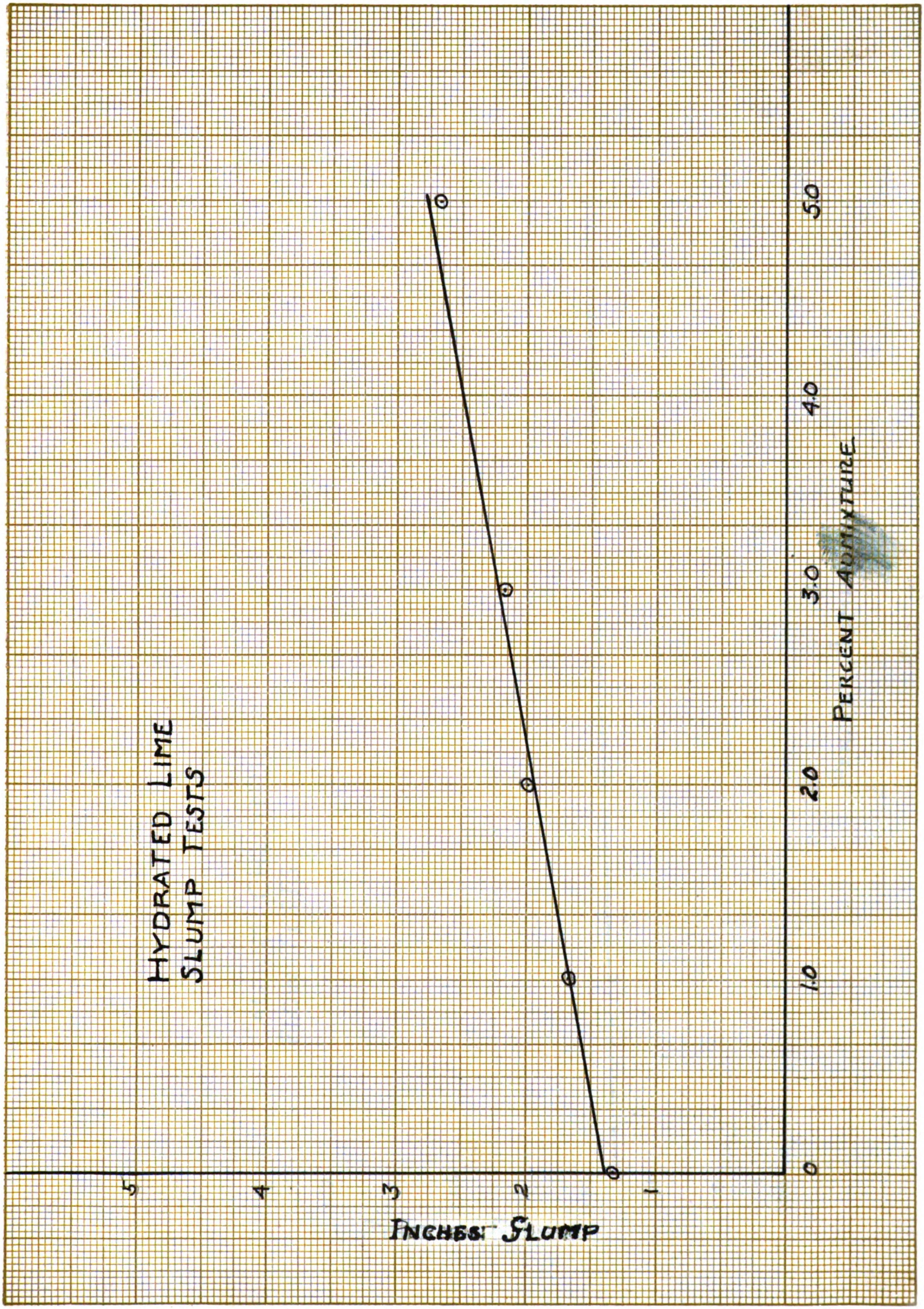
4.0
4.5
5.0


HYDRATED LIME
FLOW TESTS
PERCENT ADMIXTURE
0.0
1.0
2.0
3.0
4.0
5.0
PERCENT FLOW
100
110
120
130
140
150
160
170
180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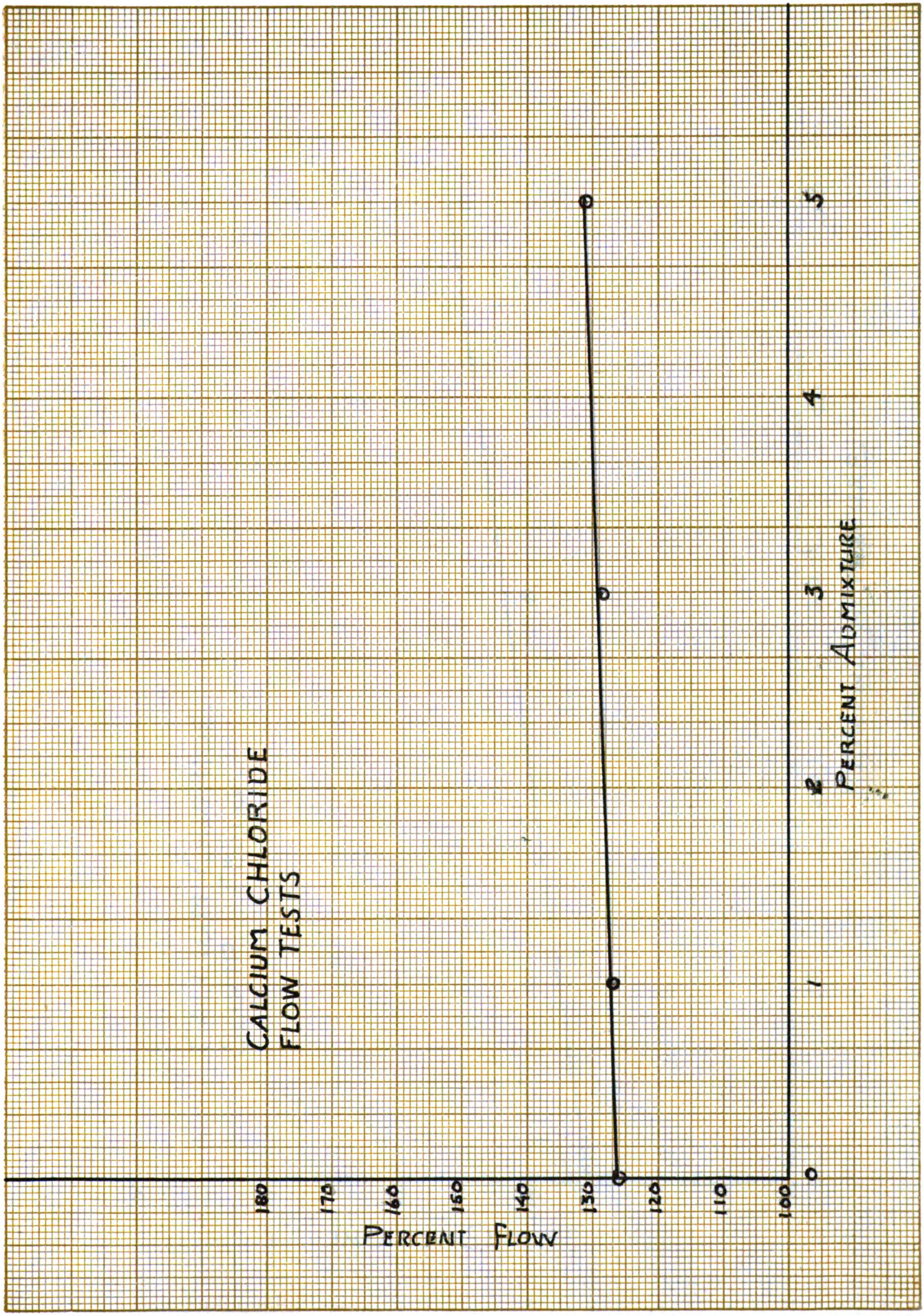
2.0
3.0
4.0
5.0
INCHES SLUMP
1
2
3
4
5


CALCIUM CHLORIDE
FLOW TESTS
PERCENT FLOW
180
170
160
150
140
130
120
110
100
PERCENT ADMIXTURE
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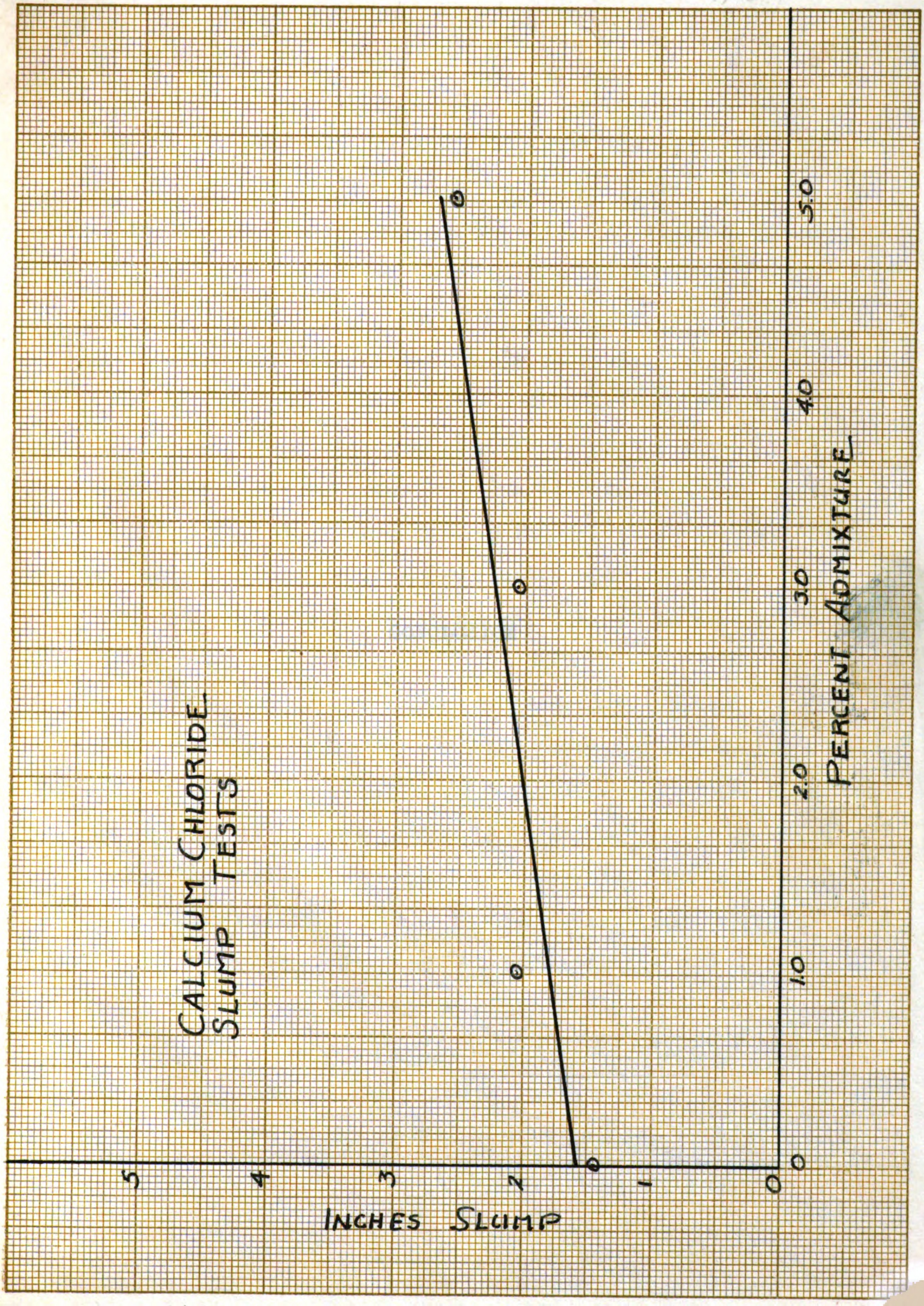
1
2
3
4
5


CALCIUM CHLORIDE
SLUMP TESTS
PERCENT ADMIXTURE
INCHES SLUMP
0
1.0
2.0
3.0
4.0
5.0
0
1
2
3
4
5

CONCLUSION

CONCLUSION

The results secured in these investigations seem satisfactory in their indications of the effect of these different admixtures on theworkability of a concrete mix. It is, however, admitted that the results of this research are hardly more than an indication, leaving room for much more investigation in search of more complete knowledge of theeffect of these admixtures on workability.

Vinsol resin and Orvus, air-entraining agents, probably increased workability due to replacement of water by entrained air, thereby having the effect of increasing the amount of mixing water. Also, the additional air incorporated probably acted in some measure as water in making the mix mobile.

The effect of Pozzolith on workability seems the greatest of any admixture used. A dispersing agent like Pozzolith has the effect of breaking down the cement floc, andin doing so releases water which has been trapped within the particle clumps. Then this water becomes a part of the mixing or placing water. Also, Pozzolith does entrain some air. This, too, adds to mobility. These,it seems logical, were the actions that resulted.

Hydrated Lime and Calcium Chloride effected the workability of the mix very little, as indicated by the flow tests. The slump increased to greater extent, however, with the percent of admixture added. It is the author's own

conclusion that this was due to the greater ratio of fines in the gradation used for the slump tests. In this test coarse aggregate was used, where in the flow test the mix included fine aggregate only, and adding more fine material had less effect.

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